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Consequent Management of Malevolent Use of Radioactive Material

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Overview

- Goals of enhanced security
- IAEA Code of Conduct
- Prioritization of risk-significant radioactive materials
- Developing risk-based security requirements
- Interactions with law enforcement & licensees
- Learning from international accidents
- Incident response & consequence management
- Protective Action Guides
- Risk management & communication
- Conclusions

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A Changing Environment

- National security is dominant concern
- Obtain appropriate balance between safety &
  - Security initiatives &
  - Operational activities
- Multiple layers of systems, infrastructures for various licensees

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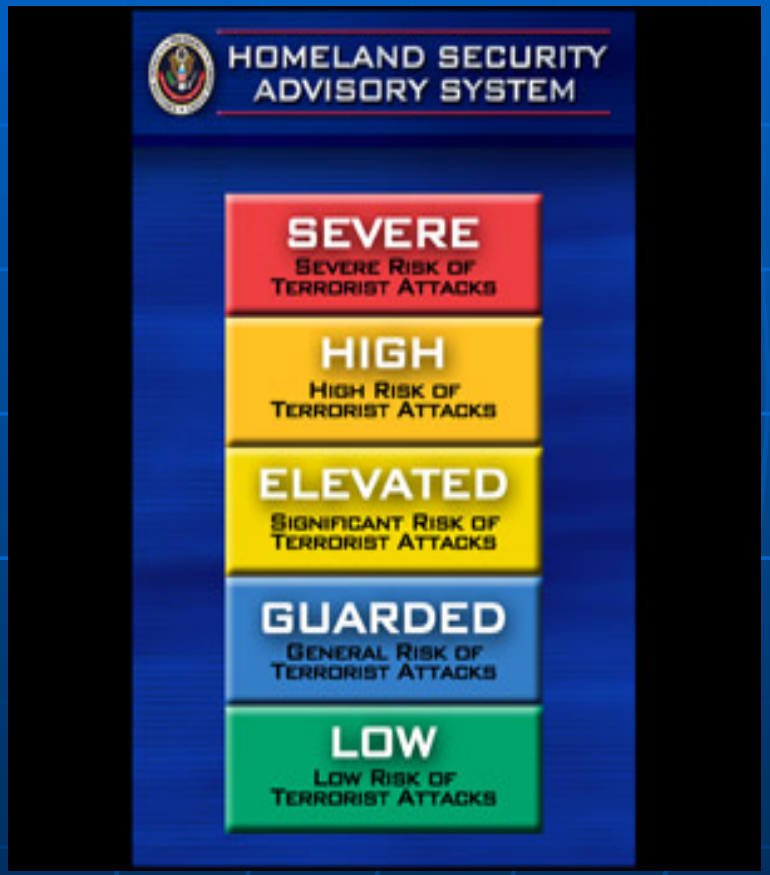
Deal with probabilities …..



Not possibilities . . .

??? What If ???

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Radiological Dispersal Device, RDD

Definition: Any device – other than a nuclear yield-capable device – specifically designed to spread or utilize radioactive material to cause destruction, damage, or injury.

- May be fine powder, liquid or gas
- Device may be incorporated in a conventional explosive device

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Radiological Exposure Device, RED

Definition: A device whose purpose is to maliciously expose people to radiation, rather than to disperse radioactive material into the air, as would an RDD.

- Device may be hidden
- Target may be a public area or mass transit to unknowingly expose people passing by

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RDDs & REDs

Potential Consequences

- People – Contamination and/or exposure
- Environmental – Localized contamination for RDDs
- Psychological impact – Terror/fear
- Local economy – Denial of access to infrastructure & property resulting in interruptions and losses
- Injury
  - REDs: Possible early or latent health effects
  - RDDs: From explosion
- Death
  - REDs: Unlikely due to time, shielding & distance factors
  - RDDs: Few deaths would occur due to the radioactive nature of the event

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U.S. NRC Research

- Evaluating consequences of inadvertent uses of radioactive materials since the early 1970s
- Casualties unlikely
- Contamination used as a surrogate indicator of potential consequences
- In 2002, U.S. NRC-DOE RDD report specified & evaluated sources of greatest risk
- In 2003, countries work with IAEA to further define "risk-significant" radioisotopes of concern and issue revised *Code of Conduct*

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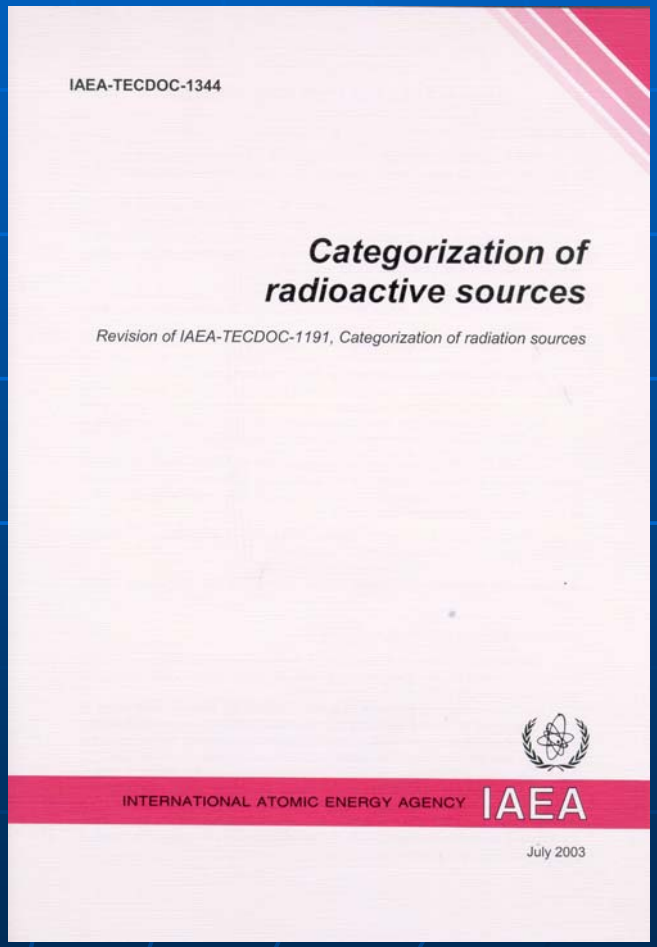
Strengthening Security

- Security is important, but . . .
- Safety of sources still paramount
- IAEA-TECDOC-1344
- Issued July 2003
- Lead to IAEA's *Code of Conduct on the Safety and Security of Radioactive Sources*



See http://www-pub.iaea.org/MTCD/publications/PDF/te_1344_web.pdf

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IAEA Code of Conduct

- Published in final form in January 2004
- Code applies to the top three risk-significant source categories as defined by IAEA TECDOC-1344 (now RS-G-1.9)
- Code's scope is further limited to Category 1 and 2 for:
  - National source tracking registry
  - Import/export provisions

See http://www-pub.iaea.org/MTCD/publications/PDF/Code-2004.pdf

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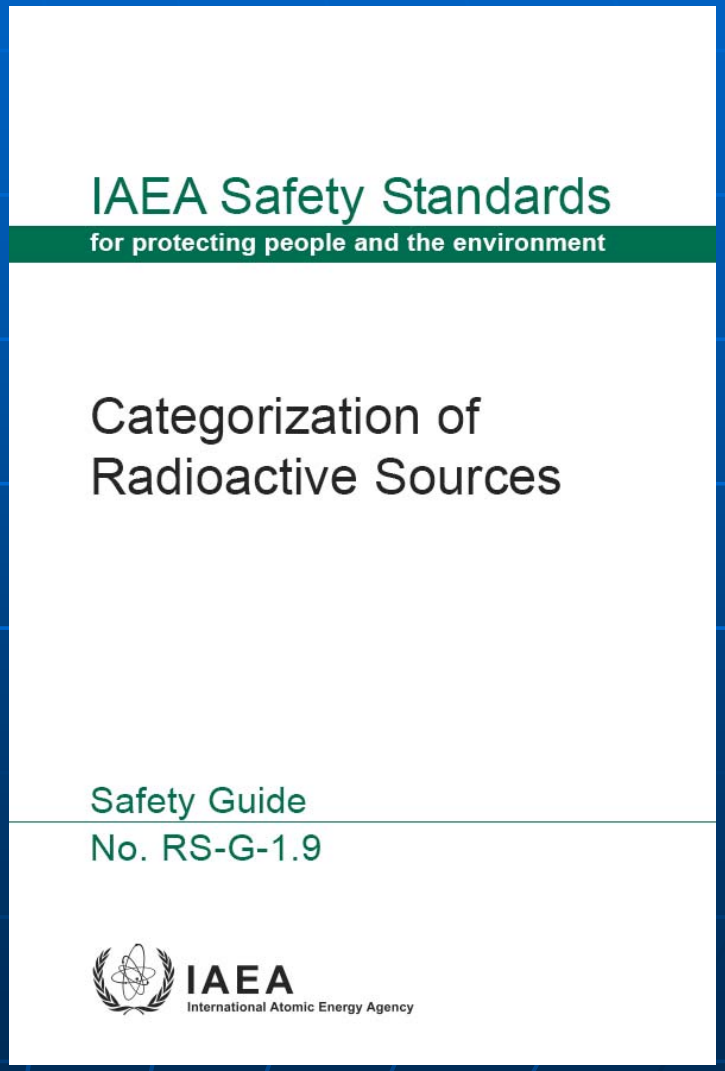
Categorization of Sources

- Safety Guide No. RS-G-1.9 (Replaces TECDOC-1344)
- Issued 2005



See http://www-pub.iaea.org/MTCD/publications/PDF/Pub1258_web.pdf

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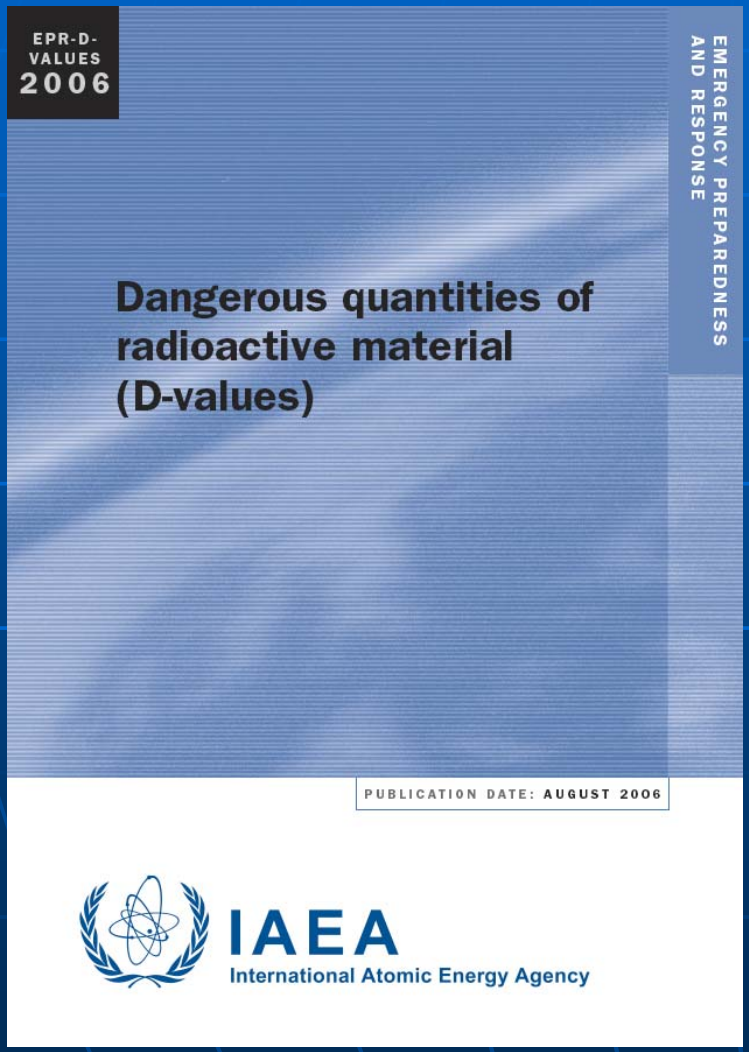
IAEA D-Value



- Provides guidance on quantities of radioactive material that may be considered dangerous if uncontrolled
- Part of an IAEA emergency Preparedness and Response Series

* *See* http://www-pub.iaea.org/MTCD/publications/PDF/EPR_D_web.pdf

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Selected IAEA Source Categories Requiring Increased Security

Radionuclide	Category 1 Sources		Category 2 Sources	
	TBq	Ci	TBq	Ci
Am-241/Be	60	2000	0.6	16
Co-60	30	800	0.3	8.1
Cs-137	100	3000	1	27
Ir-192	80	2000	0.8	22
Pu-239/Be	60	2000	0.6	22
Pm-147	40,000	1,000,000	400	11,000
Sr-90 (Y-90)	1000	30,000	10	270

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Tracking Processes for Radioactive Materials

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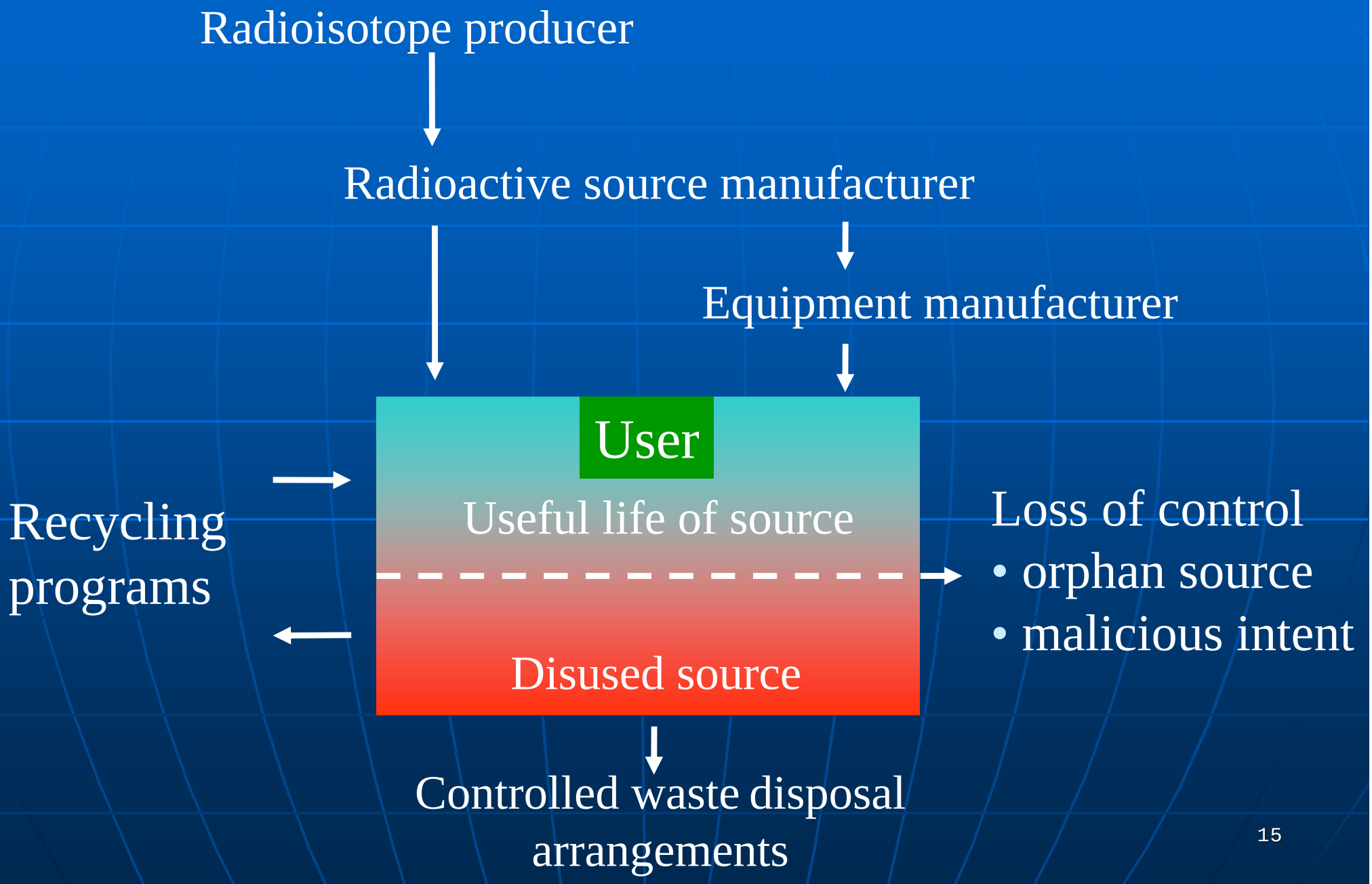
Cradle to Grave



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Interim Database

- Begin with a survey of licensees
- A ‘snapshot’ in time, update on annual basis
- IAEA Category 1 and 2 sealed sources
- Aggregation considered so some Category 3 sources are included
- Data considered *Official Use Only*
- Collected basic data
- Data used to inform security enhancements, advisories, & inform National Source Tracking system
- Will be periodically (~annually) updated

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New National Source Tracking System

- IAEA *Code of Conduct* recommended establishment of a national registry
  - IAEA Category 1 and 2 sources
    - U.S. approximately 55,000 sources
  - NRC collecting information for Category 3 sources
  - Operational by early 2009
- U.S. legislation (Energy Policy Act of 2005) placed requirements for NRC to issue regulations establishing a mandatory tracking system
- US Government has made a non-legally binding commitment to the Code of Conduct

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Orphan Source Initiatives

1. Maintain control of sources – U.S. NRC Examples
   - Lost Source Enforcement Policy (2001)
   - General License Tracking System (2002)
   - Proposed Rule on Portable Gauges (2003)
   - National Source Tracking System (2006)
   - Proposed Rule on Generally Licensed Devices (2008)

2. Recover sources that become orphaned
   - U.S. DOE Offsite Source Recovery Program (1990)
   - Trilateral Initiative with US/Mexico/Canada (2002)

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IAEA Code of Conduct Import & Exports

- Recipient country has Regulatory infrastructure
- Recipient is authorized to receive/possess sources
- Prior notice of Categories 1 & 2 sources
- Prior consent for shipments of Category 1 sources
- Exceptional circumstances

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Import & Exports

- Export licenses can be issued for multiple high-risk radioactive materials, multiple countries & recipients
- U.S.NRC (Regulator) contacts known recipient countries of U.S. origin risk-significant radioactive material
- Regulator may request recipient countries to authorize release of IAEA mission reports (Official Use Only) to further assess programs for controlling radioactive material
- Regulator will verify country's authorization to possess material for its licensees
- U.S. final rule completed Dec 2005

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The Challenge of Code Implementation: World-Wide

- Some countries may lack the enabling legislation and/or regulatory infrastructure needed to fully implement the Code
- Situation presents challenge to developed countries who desire to export sources to nations who lack many of the elements of policy and programmatic controls for the safe/secure management of sealed sources
- “Lessons Learned” & training at conferences help countries in implementing the Code

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Security Initiatives

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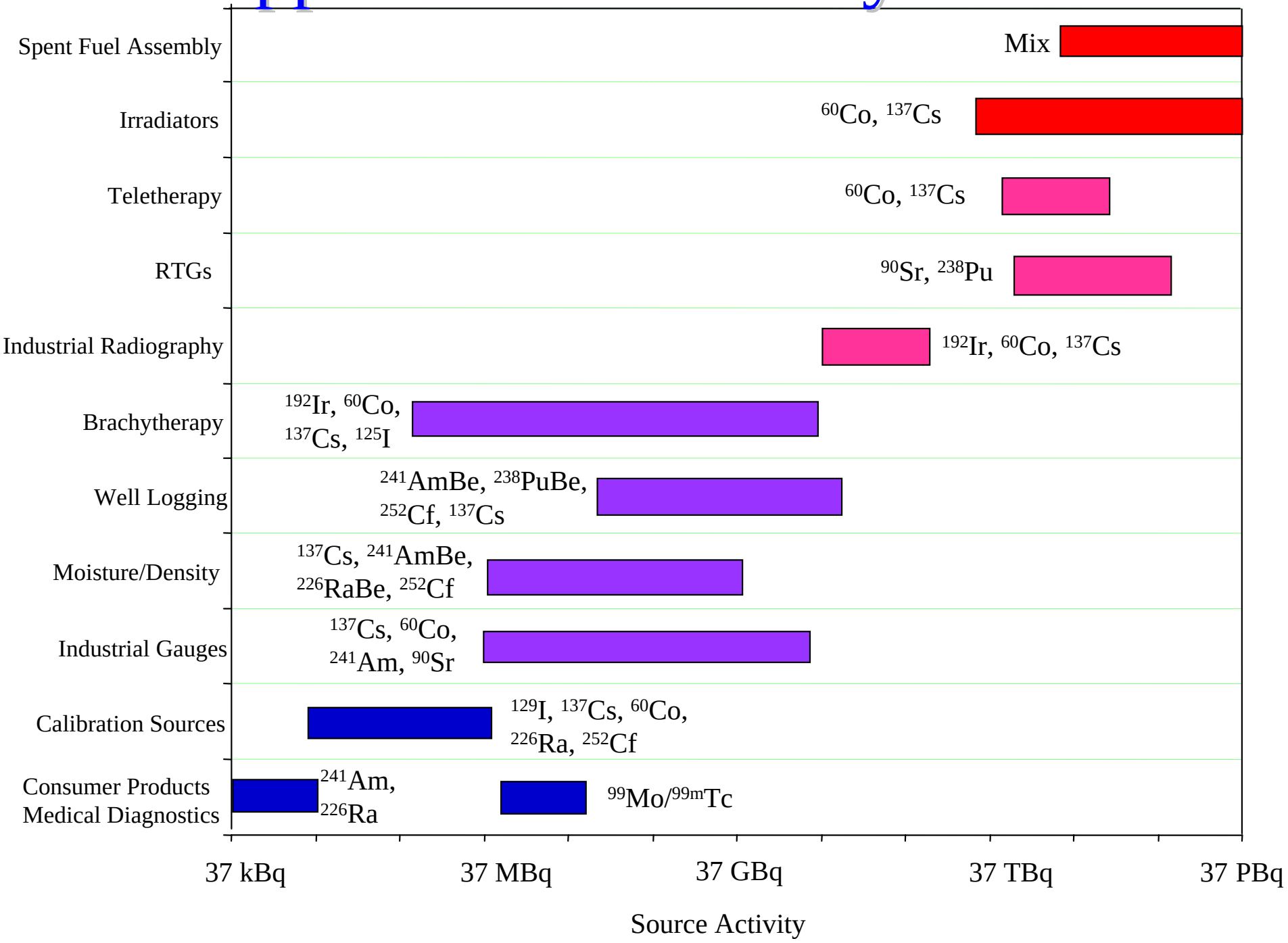
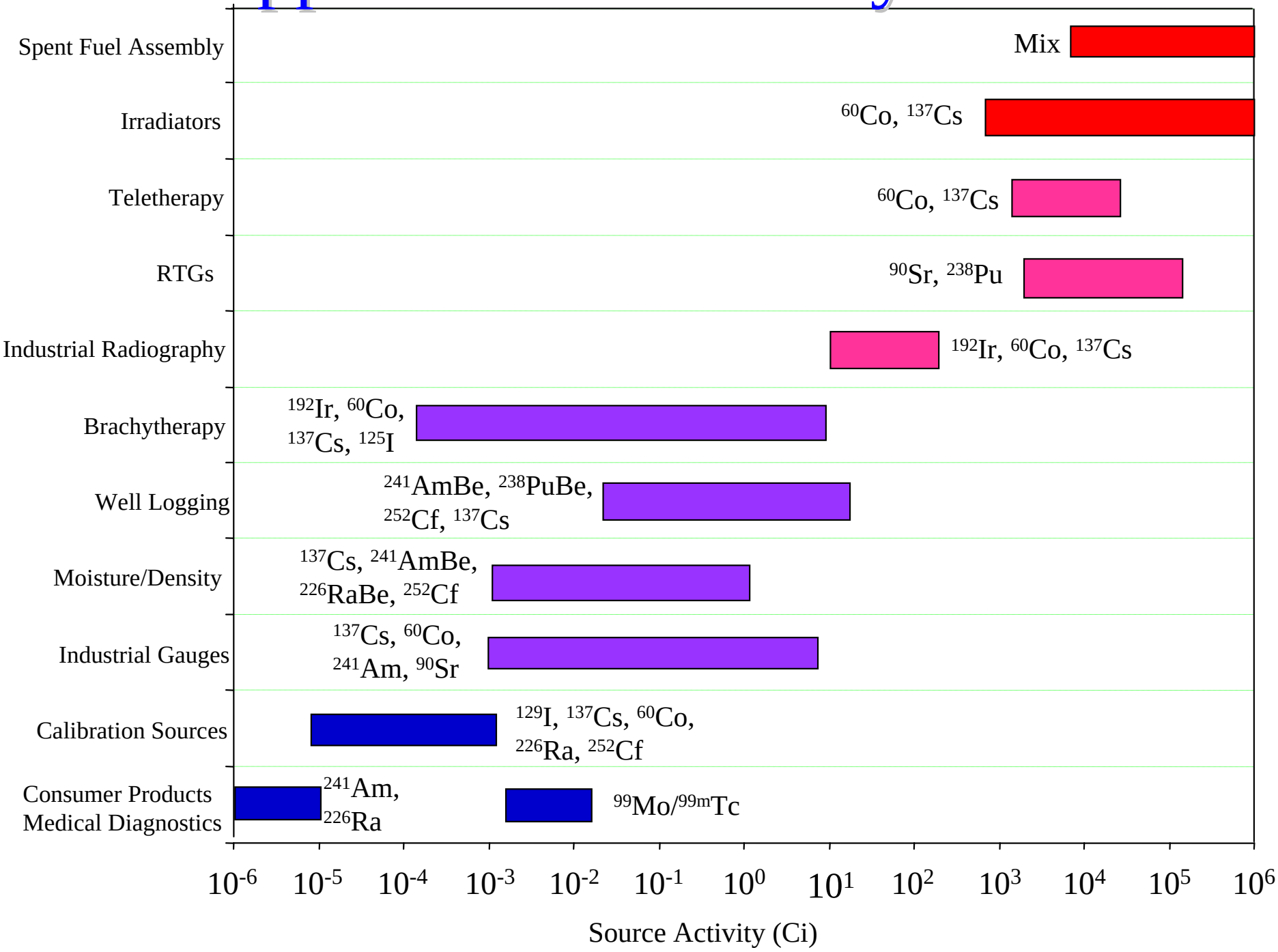
Goals of Enhanced Security

- Enhance existing security and control using practical measures
- Focus on risk-significant radioactive sources
- Conduct vulnerability analyses of materials licensees and sources
- Reassess license authorizations
- Confirm shipping/receiving
- Prevent theft/diversion for malevolent use
- Prompt detection, assessment, and reporting
- Prompt Local Law Enforcement Agency response
- Add security for radioactive materials in transit
- Enhance Import/Export controls
- Develop and implement revised inspection procedures

Application & Activity Matrix



Application & Activity Matrix



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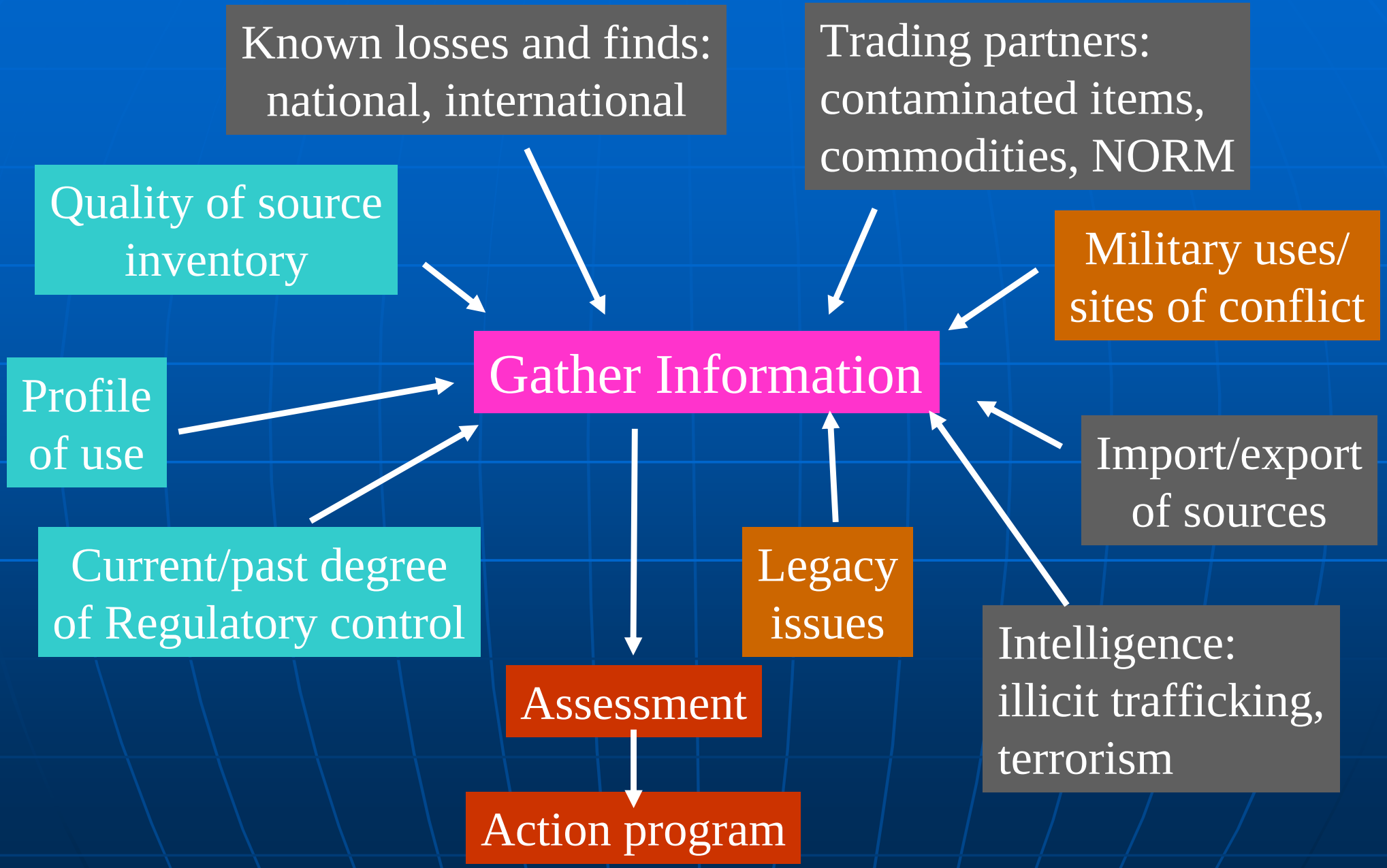
Assessment of Threats



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Prioritization of Sources

- ***High priority*** – Panoramic irradiators (>10,000 Ci) & Manufacturers / Distributors of sources
- ***Medium priority*** –
  - Panoramic irradiators (<10,000 Ci)
  - Self-shielded irradiators (e.g., blood irradiators)
  - Teletherapy devices
  - Gamma knife devices
  - High and medium dose rate afterloaders
  - Radiographers & Well loggers
  - Broad scope licensees
  - Calibration Sources
- ***Low priority*** – Portable gauges

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New Security Requirements

1. Large Panoramic Irradiators Security Measures
2. Manufacturing and Distribution Licensees Security Measures
3. Transportation of Radioactive Material Quantities of Concern
4. Orders for Increased Security Measures for other types of sources by categories of licenses

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Panoramic Irradiator Security

- Pre 9/11 Requirements
  - Secure materials in storage from unauthorized removal or access
  - Control and maintain constant surveillance of material that is not in storage
  - Control access to prevent inadvertent entry
  - Radiation monitors

- Post 9/11 Required Security Enhancements
  - ASM 1 Security Zone
  - ASM 2 Access Control
  - ASM 3 Background Investigations
  - ASM 4 Monitoring, Detecting, Assessing, and Responding to Intrusions
  - ASM 5 Liaison with Local Law Enforcement Agency
  - ASM 6 Protecting Against Unauthorized Disclosure of Sensitive Unclassified Information

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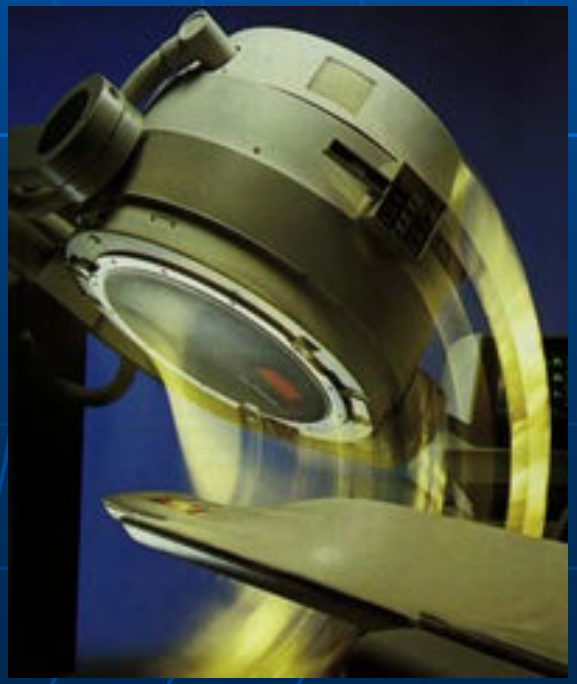
Prioritized Licensee Groups:

- *High priority*- Panoramic irradiators; manufacturers & distributors
- *Medium priority* – medical and research facilities, radiography, well-logging, broad-scope licenses, self-shielded irradiators, open-field irradiators, and other licensees
- *Low priority* – Portable gauges



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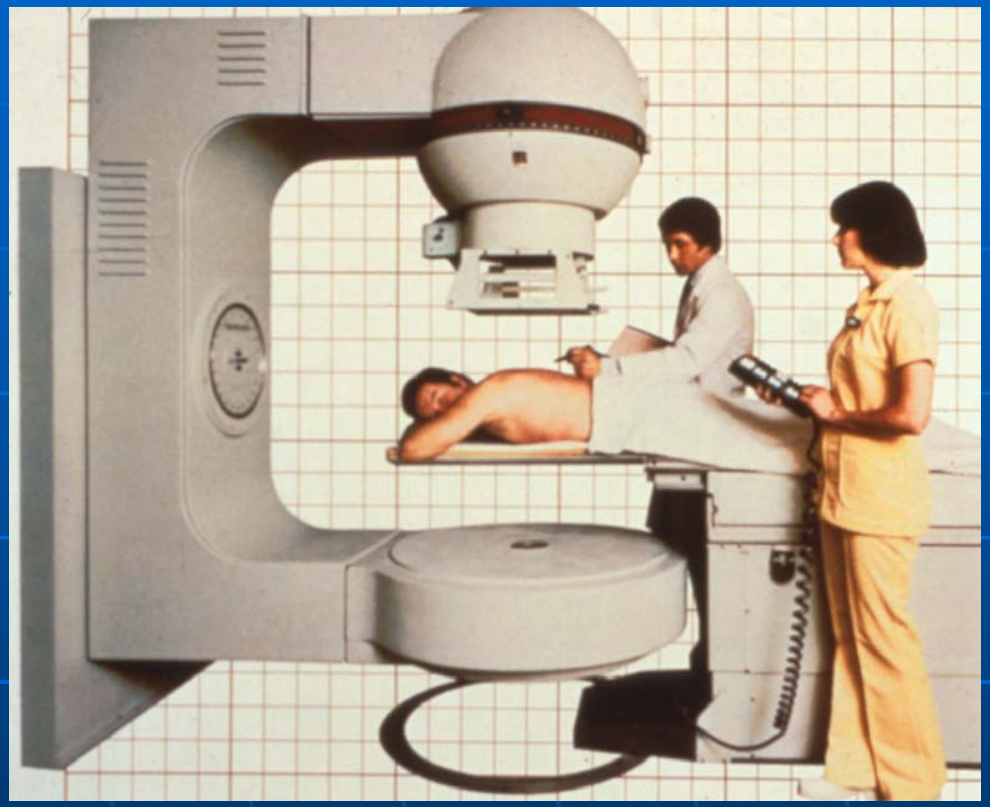
Medical Teletherapy



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Self-shielded Irradiators

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Blood Irradiator Security

- ***Pre 9/11 Requirements (USNRC 10 CFR Parts 20 & 36)***
  - Secure materials in storage
  - Control and maintain constant surveillance

- ***Post 9/11 Required Security Enhancements (Issued by NRC & States)***
  - SC-1: Control Access (includes trustworthy and reliability)
  - SC-2: Monitor, Detect, Assess, and Respond (Law enforcement coordination)
  - SC-3: Ensure Transportation Security (requirements for carriers, confirmation of shipping/receiving)
  - SC-4: Control portable and mobile devices (additional delay devices)
  - SC-5: Retain Information
  - SC-6: Protect Security Information


DANGER
RADIOACTIVE MATERIAL
AMERTEST 660
N.F.F.

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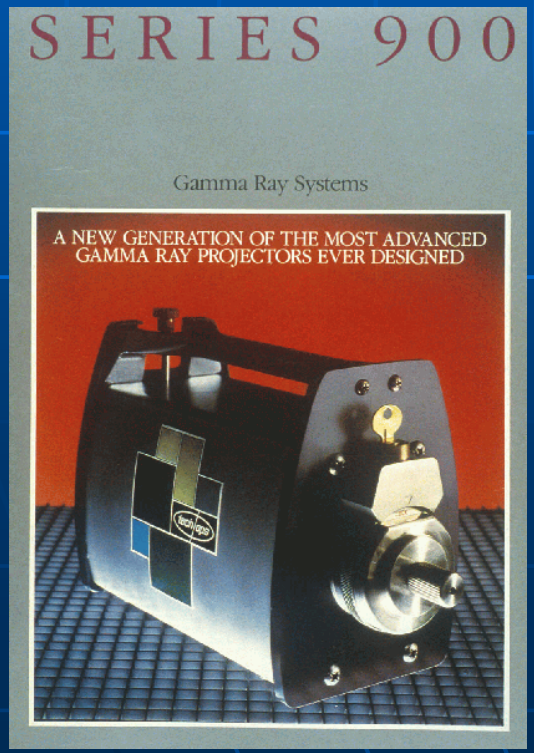
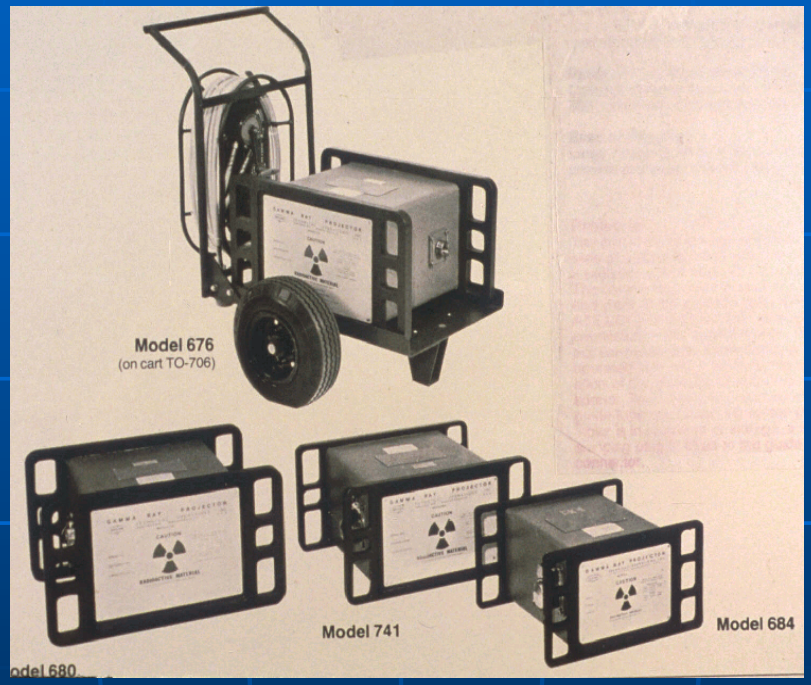
Radiography





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Radiography Source

Actual Source 2mm x 2mm

Radiography Camera

Radiography "pigtails"

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Enhanced Security Activities

Prioritized Licensee Groups

Well loggers

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Increased Security Measures

- Security Zone
- Control Access
- Monitor, Detect, Assess, and Respond
- Transportation Security
- Additional control to secure portable & mobile devices
- Liaison with Local Law Enforcement Agencies
- Background Investigations & Fingerprinting
- License Verification
- Document Retention
- Information Protection
- Issue legally binding requirements to licensees

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Security Inspection Results

- All Increased Control inspections completed
- Licensee communication issued May 2007
- ~ 50% of the inspections performed resulted in violations
- Licensees misinterpreted or incompletely implemented requirements
- *Common theme*: Failure to properly document actions or programs when implementing increased security controls
- Examples of violations include:
  - Monitoring, Detecting, Assessing and Responding
  - Controlling Access
  - Information Protection requirements

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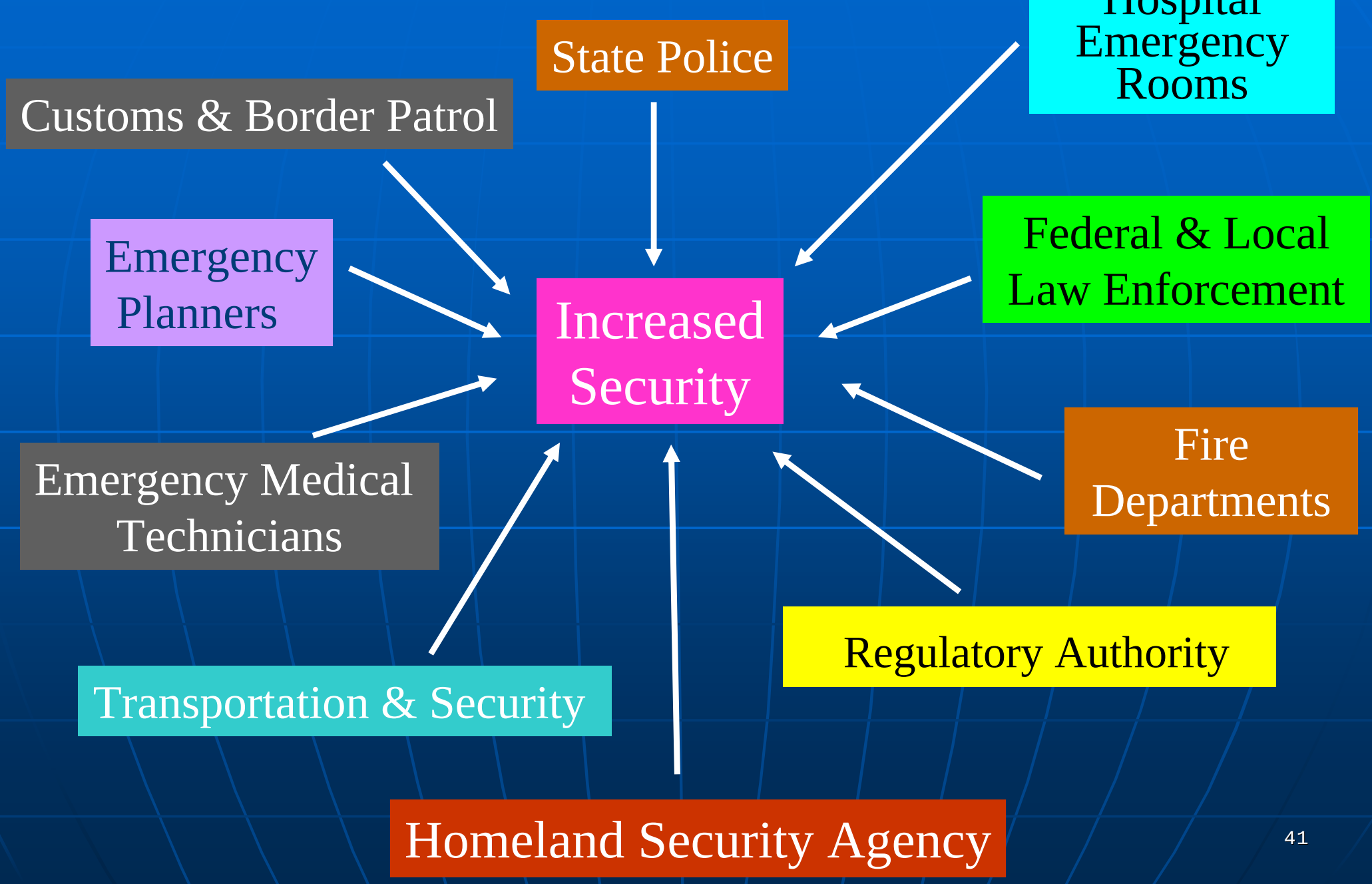

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Learning from International Accidents

Increased Risk of Loss of Control

Effective Control

Ciudad Juárez, México: An accident with ^{60}Co

Reference: Ministerio de Energia y Minas. Comisión Nacional de Seguridad Nuclear y Salvaguardias. Accidente de contaminación con ^{60}Co. CNSN-IT-001. Mexico (1984)

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Beginning of scenario

- Nov. 1977
  - A ^{60}Co teletherapy unit (~30 TBq) was purchased & imported
  - This was an illegal import (Regulatory Authority not notified)
- Nov. 1977 – Nov. 1983
  - Never reported to the authorities
  - The unit was stored in a warehouse for 6 years

Typical ^{60}Co unit

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Maintenance staff's role

- Dec. 6, 1983
  - Some maintenance staff became interested – scrap value should be high
  - He dismounted the source
  - Perforated the source container on the truck
  - Drove to a junk yard and sold it together with some other "valuable" metal pieces

A dismantled Co treatment head

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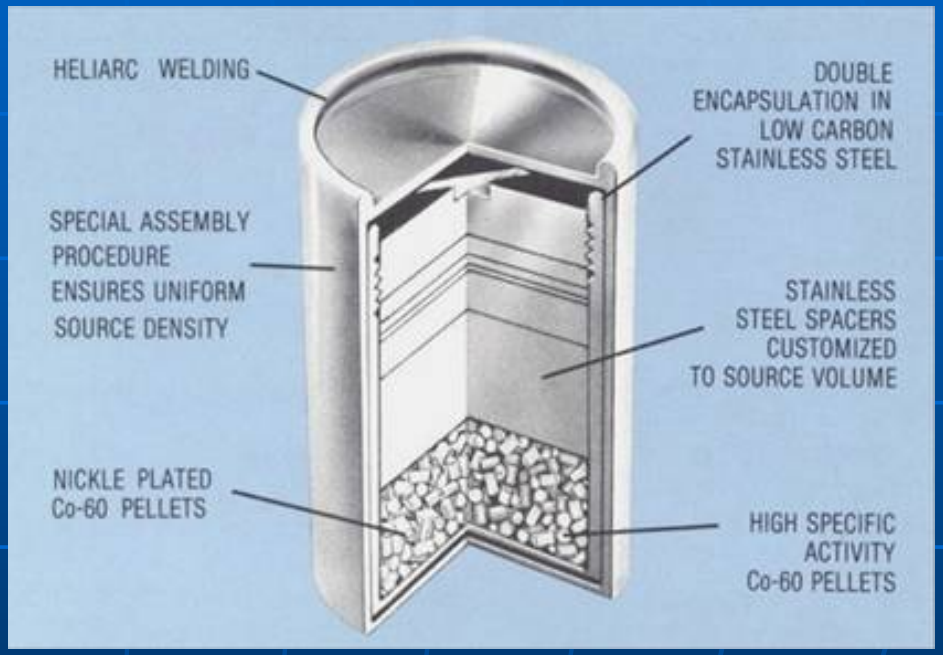
The source



Typical ^{60}Co source displaying the interior with a large amount of pellets

15 TBq or 430 Ci

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At the junkyard

- ~ 6000 pellets of ^{60}Co:
  - About a 1 mm in size
  - On the truck
  - In the junkyard – everywhere since metal scrap is moved around by cranes, *etc.*
  - Mixed with all other metal scrap
  - Other trucks moving scrap out of the junkyard
- Main purchaser of scrap constructs reinforcing rods, *e.g.* for motor vehicles, buildings
- The first truck broke down and was parked for 40 days in the village & another 10 days at a second location

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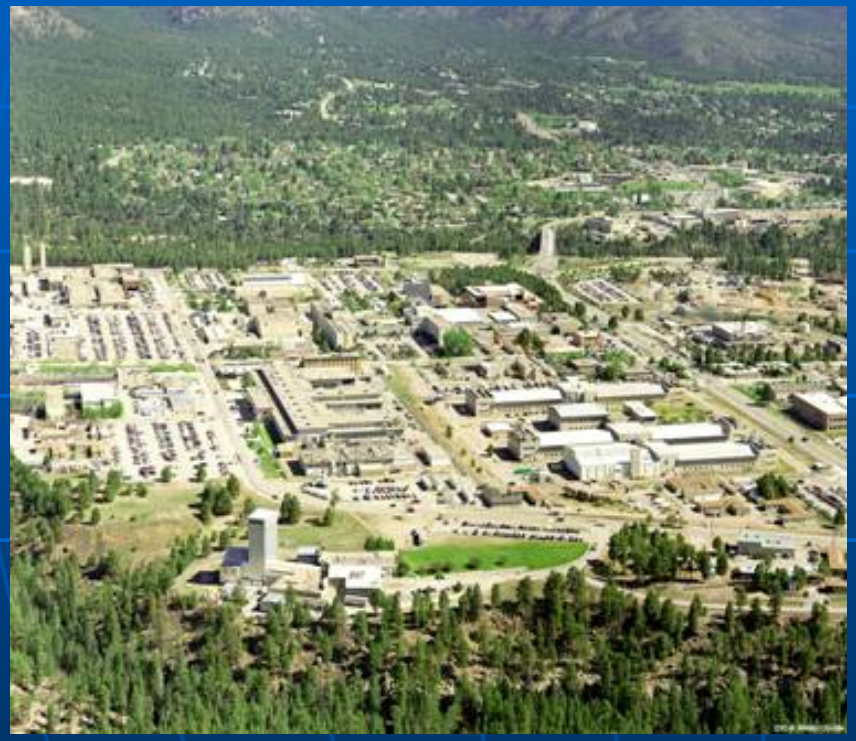
At Los Alamos



- Another company making table bases received scrap metal from the junkyard
- A truck load of tables passing the Los Alamos Nuclear Center triggered the radiation monitors
- The highway was monitored and the truck was identified
- Two days later it was determined where the activity came from

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Chronology

- Dec. 6, 1983: Treatment unit dismantled
- Dec. 14, 1983 - Jan. 16, 1984
  - Dissemination of radioactive substance
- Jan. 16-18, 1984
  - Detection of contamination and its origin
- Jan. 19-22, 1984: Investigation
- Jan. 23-Feb. 8, 1984: Corrective actions

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Extent of the accident

- ~ 4000 persons exposed
- 5 persons with doses from 3 to 7 Sv in 2 months
- 80 persons with dose greater than 250 mSv
- 18% of the exposed public received doses of 5-25 mSv
- Storage of 37,000,000 kg of rods, metallic bases, material in process, scrap iron, barrels with pellets and contaminated material, earth, *etc.*

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Range of the contamination

- 30,000 table bases produced
- 6,600,000 kg of rods produced
- Aerial survey of 470 km^2 identified 27 cobalt-60 pellets
- 17,636 buildings were visited to determine if radioactive material was used in the construction
- Too high levels in 814 buildings
  - Partly or completely demolished

Reinforcement rods (Rebar)

How can this experience be applied in responding to an RDD accident?

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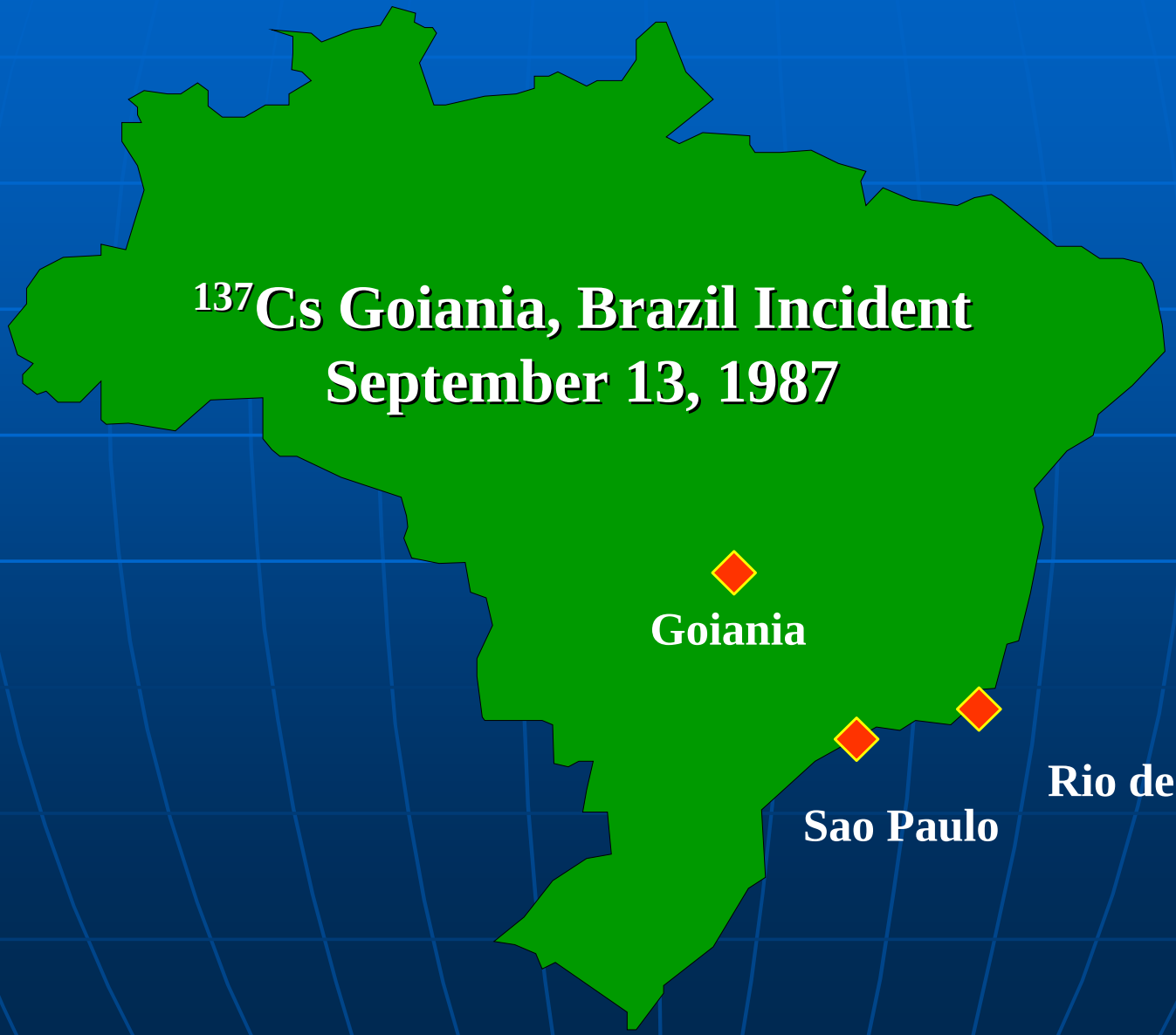
Cs-137 Incident
Goiânia, Brazil (1987)



Effective Control

Licensing & Registration

Purchase/installation

Normal usage

Increased risk modalities

Challenging events

Maintaining knowledge

Disused sources

Planned authorized disposal

Increased Risk of Loss of Control

Illegal acquisition

Long term storage before use

Poor safety/security

Maintenance
Use of mobile sources

Lack of emergency preparedness plans

Loss of key staff
Bankruptcy

No clear future
Disposal costs
Dismantling of plant

Orphan sources

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Goiânia, Brazil 1987

50 TBq ^{137}Cs Teletherapy source

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Goiânia, Brazil 1987

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Removal of the source


13 - 18 September

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The travelling source

September 22-24

Junkyard 1

Bar

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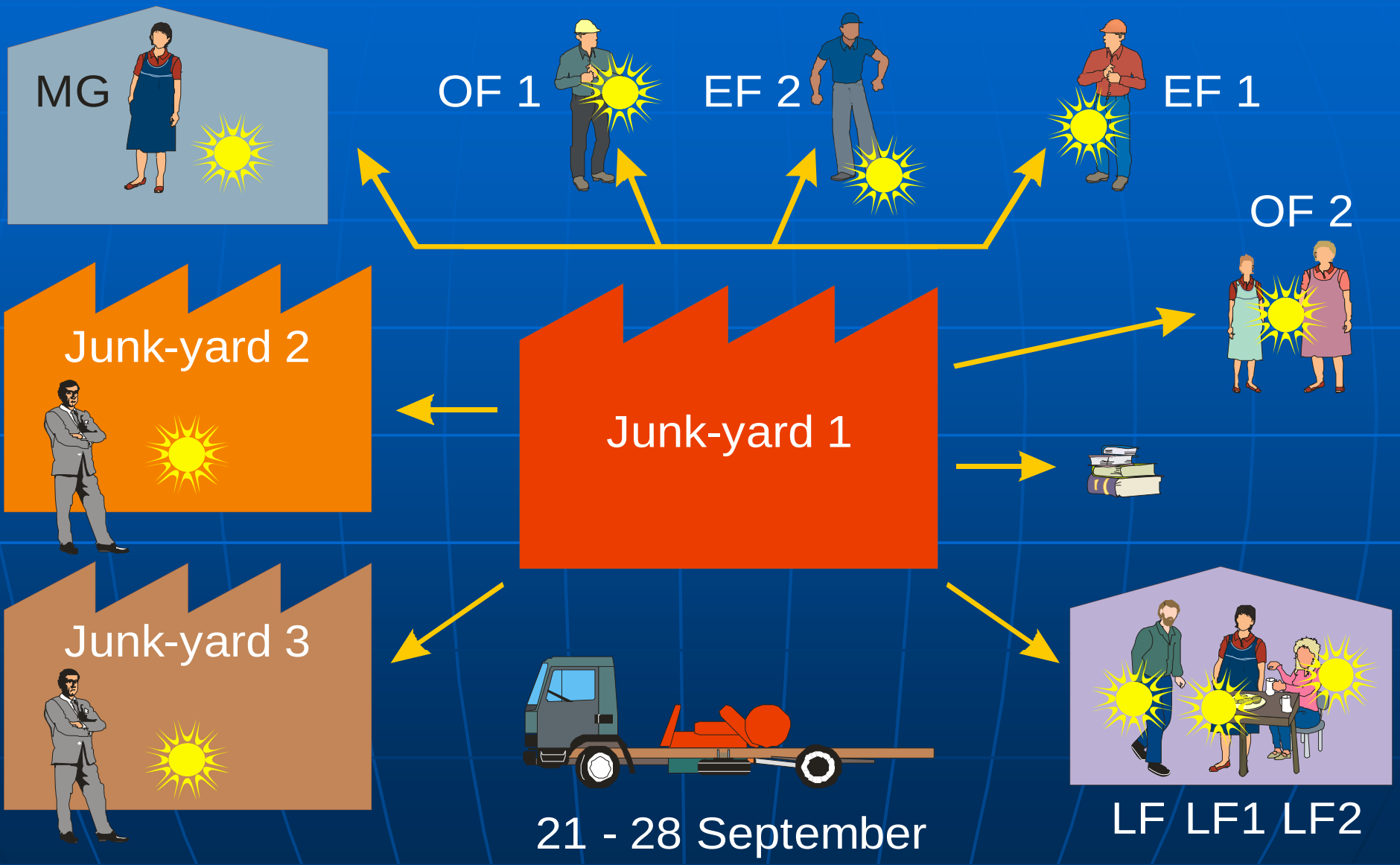
Goiânia Accident Involving ^{137}Cs



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Goiânia: Localizing the Activity

26 mi^2 monitored

7 major sites
42 other sites

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Goiânia: Countermeasures and Actions

200 people evacuated
- Top soil removed

85 houses decontaminated
7 houses demolished

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Goiânia: Generated Waste

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Goiânia: Monitoring Programs

- 112,000 people
- Bus fleet used

How dissimilar would this response be if it were an RDD accident?

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Goiânia Lessons: Results & Recovery

- Four casualties within 4 weeks of hospital admittance (4.5 to 6 Gy)
- Two patients with similar doses survived
- 112,000 persons monitored, of whom 249 were contaminated internally or externally
- Environment severely contaminated; decontamination
- Investigation level: 5 mSv 1st year and a long term projected dose of 1 mSv y^{-1} in subsequent years
- Logistics
  - Staff resources and training
  - Suitable equipment
  - Back-up facilities
- Contingency plans for temporary waste storage 20 km away

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Emergency Response to Radiological Incidents

Enhancing preparedness to RDDs by gaining insights from responses to international source accidents

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Protective Action Guides (PAGs)

- PAGs – The projected dose to a reference individual from an unplanned release of radioactive material at which a specific protective action to *reduce or avoid* that dose is recommended

- Protective Action – An activity conducted in response to a nuclear incident in order to reduce or eliminate exposure to members of the public to radiation or other hazards
  - e.g., shelter, evacuate, washing, alternate food/water sources

Developed for use in all incidents of radiological release to the environment

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Protective Action Guides for RDDs

- Based on EPA's 1992 *Manual of Protective Action Guides and Protective Actions for Nuclear Incidents**
- Guidance represent U.S. Federal consensus
- Early phase guidelines: 10-50 mSv, with an understanding that doses above 50 mSv may be unavoidable for first responders performing life saving missions
- Intermediate phase: 20 mSv first year
- Late phase (subsequent years): 5 mSv/yr projected dose
- U.S. published final guidance August 1, 2008

**Report No. EPA 400-R-92-001*

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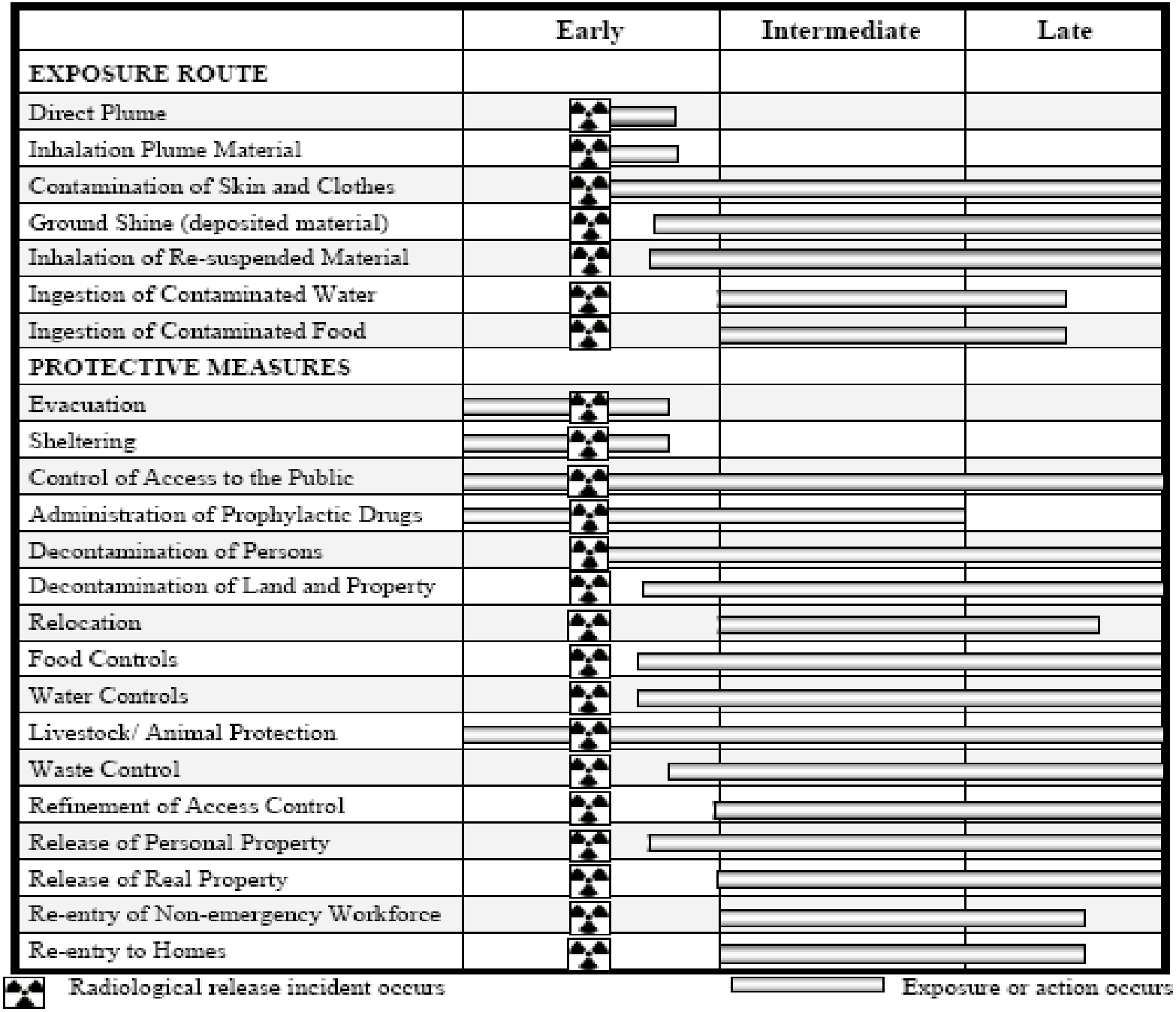
Phases of Response

- ✓ *Early Phase* (Emergency Phase)
  - Immediate decisions are required
  - Included initial emergency response actions to protect public
  - Decisions usually made by elected or government officials
- ✓ *Intermediate Phase*
  - Begins after incident source releases are under control
  - Critical infrastructure reopens
- ✓ *Late Phase*
  - Recovery and cleanup actions begin
  - Phase ends when remediation actions have been completed
  - Decisions usually made with stakeholder involvement - Optimization

PHASE	PROTECTIVE ACTION	RDD PROTECTIVE ACTION GUIDE
Early	Limit emergency worker exposure	5 rem, higher values under emergency circumstances as needed
	Shelter-in-place	1-5 rem projected dose, normally initiated at 1 rem
	Evacuation	1-5 rem projected dose, normally initiated at 1 rem
	Administration of prophylactic drugs	For KI, see specific government guidance dose values. For other drugs, consider on an ad hoc basis
Intermediate	Limit worker exposure	5 rem (in compliance with occupational regulations)
	Relocation	2 rem, projected dose 1st Year
		Subsequent years: 500 mrem projected dose
	Food interdiction	500 mrem projected dose
	Drinking water interdiction	500 mrem projected dose (new)
Late	Final cleanup actions	Site-specific optimization; implementation process

Figure 1: Relationship between Exposure Routes, Protective Measures, & Timeframes for Effects[a, b]



[a]Adapted from Reference [25].

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Optimization Factors

- The PAG uses an optimization process rather than setting a specific level for the late phase because clean up feasibility and economic and other tradeoffs will be highly dependent on the specifics of the situation

- Sample optimization factors include:
  - Area impacted
  - Projected land uses
  - Overall public welfare
  - Costs and available resources
  - Public acceptability
  - Unique structures, sensitive areas
  - Type(s) of contamination
  - Health risk
  - Technical feasibility
  - Long term effectiveness

Risk Management & Communication

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Risk Management

- *Process:* To identify, evaluate , select and implement actions to reduce risk to public health & safety
- *Goal:* To make scientifically-sound, cost-effective integrated actions
- *Social, cultural, ethical, public policy and legal* considerations taken into account
- Relies on three key principles:
  - ✓ *Broad context*
  - ✓ *Stakeholder participation*
  - ✓ *Iteration*

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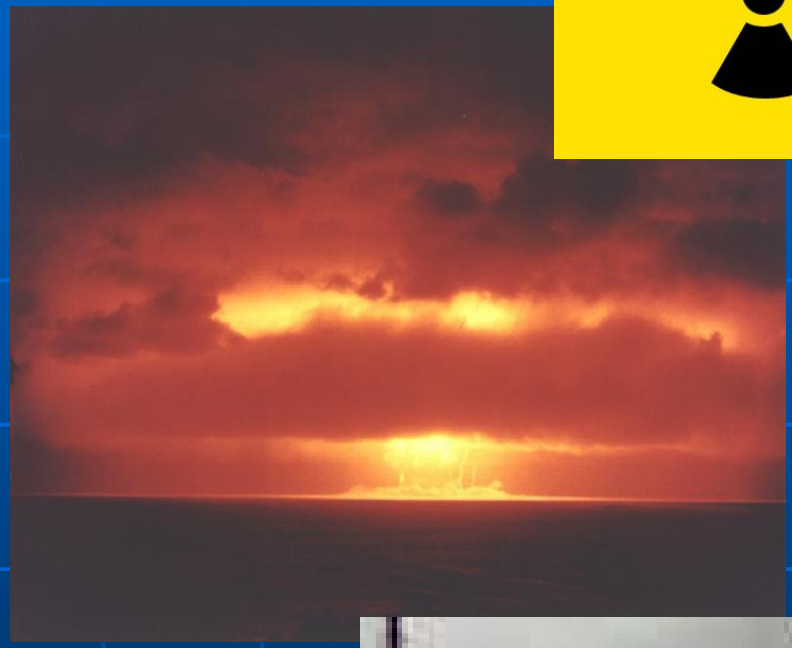
Effective Communication



- Not easy
- Sound bites galore
- Nuclear “phobia”
- Acceptability of risk
- Balance of cost & benefits
- Responsibility of the regulator, licensees and radiation protection professionals

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Thoughtful Communication: Qs to Consider

- ✓ What information is crucial to convey in initial messages?
- ✓ What are the messages to be delivered prior to, during and after an incident?
- ✓ What are the opportunities for effective communications and how can they be optimized?
- ✓ What questions can be anticipated from the public? How can panic be minimized for these situations?
- ✓ What are the news media's responsibilities? How can you help reporters meet them?

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Conclusions

- Improve and strengthen Regulatory Infrastructures worldwide
- Assess national threat
- Develop national database of Category 1 and 2 sources
- Revise existing regulations for import, export and transshipment of radioactive material
- Develop security regulations to address malicious intent for risk-significant radioactive sources
- Use a balanced approach –

Benefits vs. Prevention

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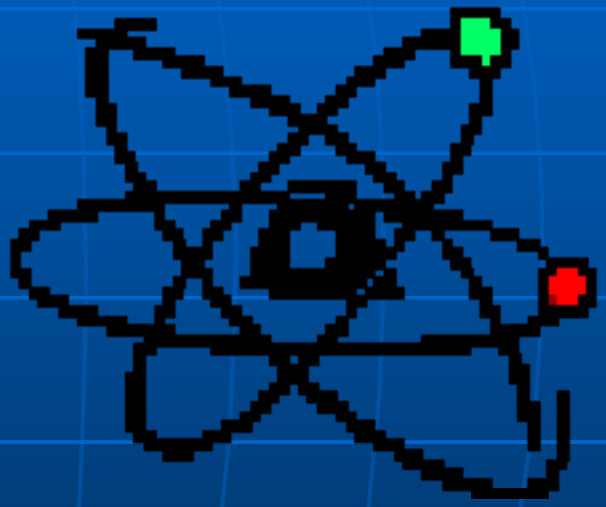
What Can We Achieve?

- Legislative Initiatives
- Advisories & Requirements
  - Nuclear power plants
  - Research & test reactors
  - Fuel conversion facilities
  - Decommissioned facilities
  - Transporters of spent fuel
  - Gaseous diffusion plants
  - Materials licensees (Academic, R&D, Medical, Industrial Users)



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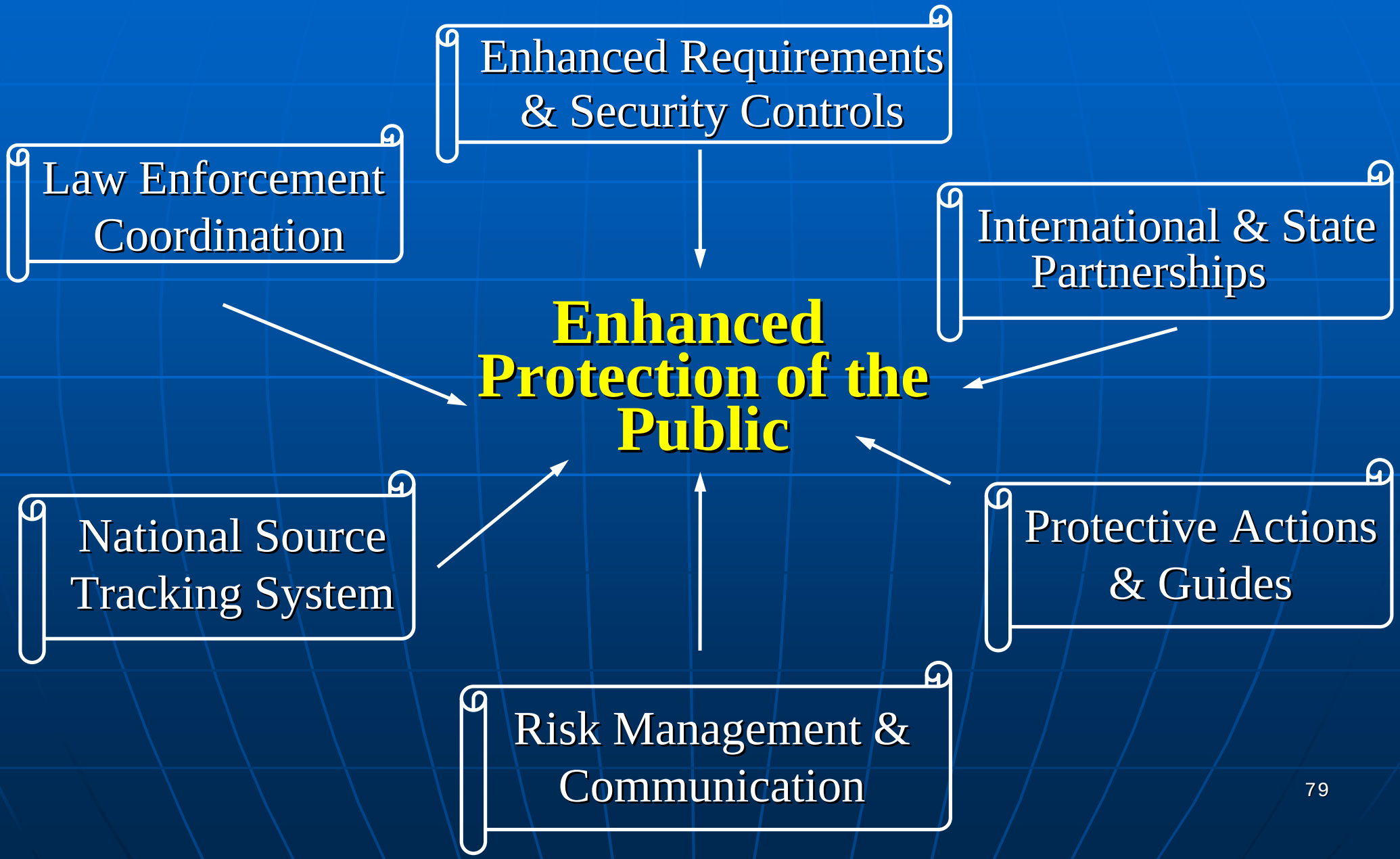
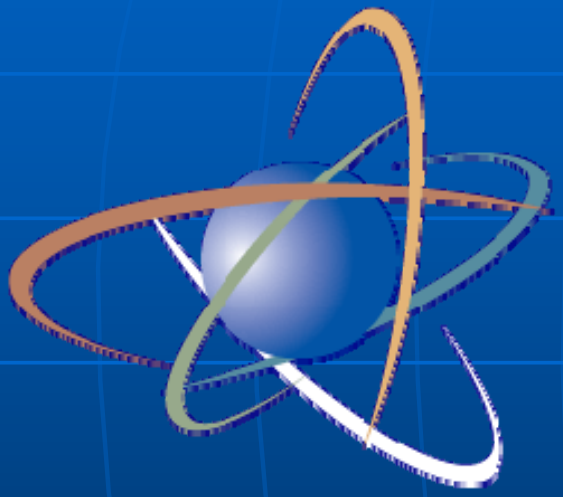
What Have We Achieved?



Thank you!



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